IQ in the Production Function: Evidence from Immigrant Earnings

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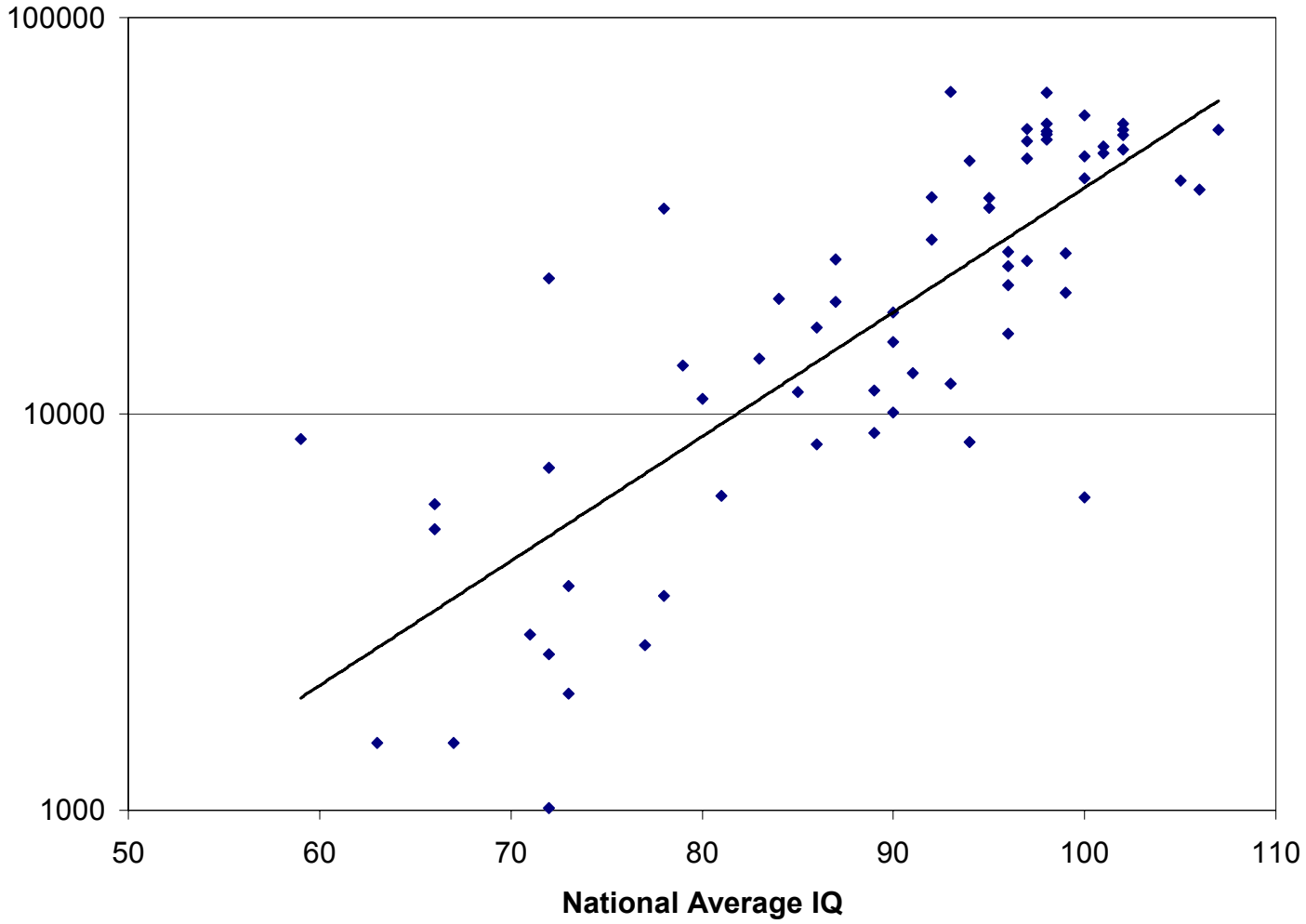
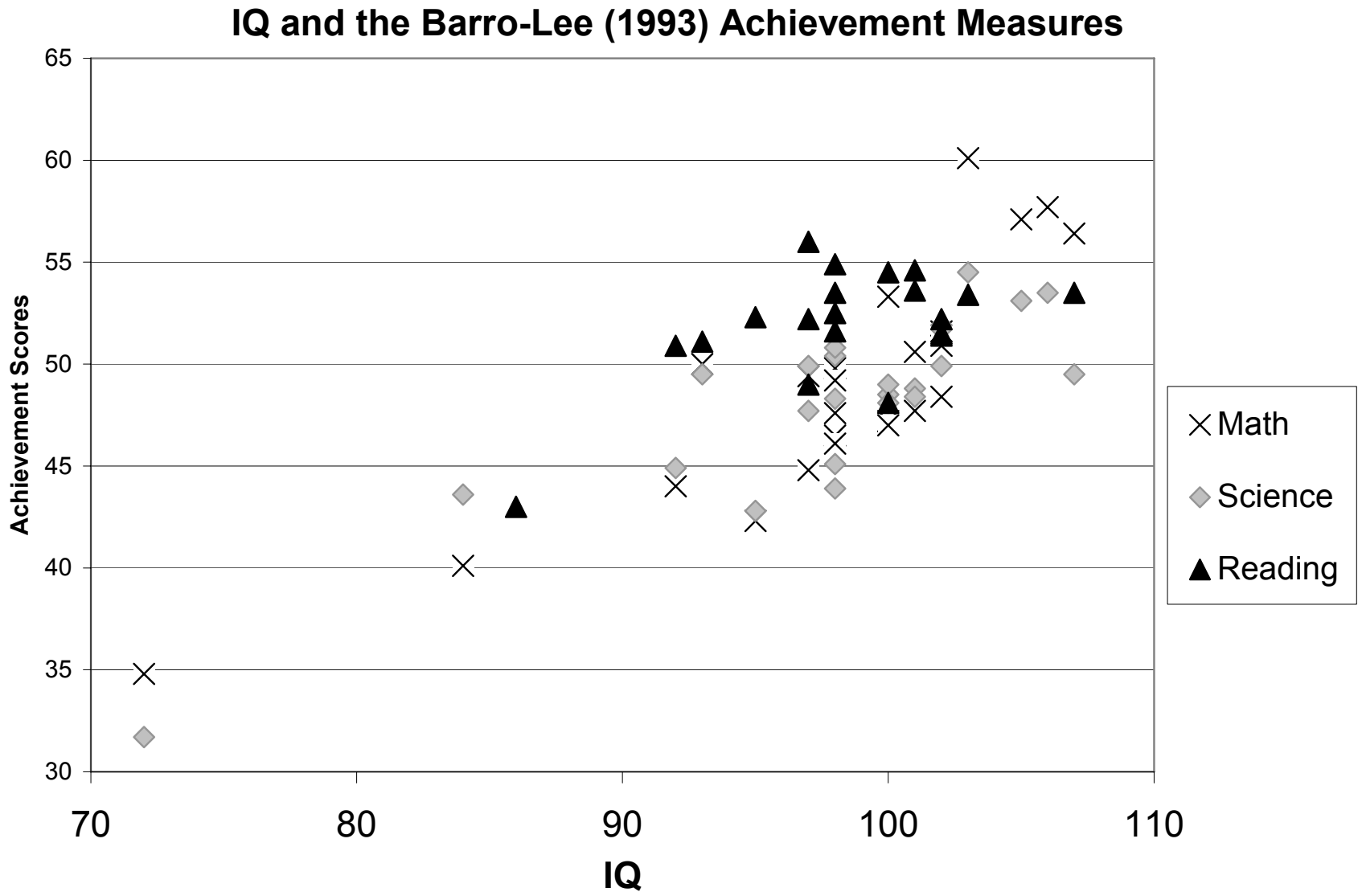
National Average IQ (Lynn and Vanhanen, 2006) and 2000 GDP per Worker (PWT)



R^2=64%; 1 IQ point ↔7.2% higher GDP per worker.
Robust to using only: Pre-1960, 1970, or 1980 IQ scores; nonverbal/culture-reduced tests.


IQ and the Barro-Lee (1993) Achievement Measures
Achievement Scores
65
60
55
50
45
40
35
30
70
80
90
100
110
IQ
Math
Science
Reading

The question addressed by this paper:

- Can IQ's impact on worker productivity roughly replicate this result via a neoclassical production function?

The answer:

- No.

Why?

- Quantitatively:
  1 IQ point↔1% higher wages at the micro level
  1 IQ point ↔6 or 7% higher productivity at the national level

- Theoretically:
  Addressed in ongoing research

IQ in the Production Function: Overview (Part 1: Micro)

- Hendricks (AER 2002): Immigrants to U.S. differ widely in "unmeasured worker skill"
- Average IQ of immigrants' home country helps measure this "unmeasured" skill
- Robust to controlling for education, outliers, and geography
- Matches a standard result from labor econ:

1 IQ point → 1% higher wages

N.B.: 1 IQ point ≡ 15^{th} of a standard deviation within U.S. or U.K population

IQ in the Production Function: Overview (Part 2: Macro)

- In a productivity accounting exercise, this IQ-wage channel can explain $1/4^{th}$ to $1/7^{th}$ of (log) cross-country income differences.

- Some hand-waving about reverse causality

- Discussion of the role of IQ in future growth research

What does IQ correlate with? ***A psychologist's perspective***

- Correlation of IQ with job performance: 0.3 to 0.5

- IQ correlates positively with occupational prestige, educational attainment, creativity, physical health, mental health, longevity, suicide.

- Cerebral glucose metabolism ($\rho \approx -0.75$)

- Nerve conduction velocity between eye and brain ($\rho = 0.37$)

- Brain size ($\rho \approx 0.4$) (All from Jensen, *The g Factor,* 1998)

- Useful metaphor: IQ as chip processing speed—not software

- Recommended: Deary, *Intelligence: A Very Short Introduction*
  Jensen, *The g Factor*

What IQ measures

- general knowledge
- verbal and spatial reasoning
- inductive and deductive reasoning
- quantitative reasoning
- verbal and memory retrieval fluency
- short-term and long-term memory
- reasoning and perceptual speed
- simple decision speed

Ex: Wechsler IQ test (WAIS-R) uses 13 subtests:

4: verbal comprehension
4: visual perception
3: working memory
2: processing speed
(Source: Deary et al., *Euro. J. Hum. Gen.*, 2006)

Why report one number, and not the distribution across IQ subtests?

- IQ's predictive validity comes from the mean
- Intellectual performance is multidimensional---but this matters little in practice
- The Full Scale IQ operationalizes the theoretical construct of *g*.
- Originally *g* was so named for the *general* factor of intelligence.
- In practice, *g* is the first principal component across IQ subtests
- Ex: Heckman et al. (1997) found that first principal component had 5X more power to predict wages than second component.

Are IQ tests biased against non-white minorities?

- Culturally loaded test items are not *relatively* more difficult for minority groups (Jensen, 1980, p. 528-529).

- Since the 1970's: No meaningful bias in IQ tests (Brown, Reynolds, & Whitaker, 1999; Jensen, 1980).

- IQ predicts important non-test outcomes equally well for these groups.

- East Asian populations—in U.S. or East Asia—outperform whites on tests written by whites.

- Brain size, electroencephalogram responses, and reaction-time tests maintain the same pattern across and within countries.

The Long-Run Rise in IQ

- Measured IQ's appear to rise an average of two to three points per decade, a phenomenon known as the *Flynn Effect*, after Flynn (1987).

- Possible explanations of the Flynn effect:
  --Genuine increase in the problem-solving ability of the population: *Health? Nutrition? TV?*

  --Teachers' greater tendency to "teach to the test."

  --More guessing on multiple-choice

- No economist has addressed this important subject. Is Flynn Effect “nominal” or “real?”

- Flynn says it recently slowed/stopped in US.

Environmental Effects on IQ

All major IQ researchers agree: The environment impacts IQ.

Example: Childhood Nutrition

- Vitamins and minerals (Copenhagen Consensus, 2004). (Fogel, Stokey, Bhagwati, Schelling, et al.)

Previous work on IQ and productivity

- Lynn and Vanhanen, IQ and the Wealth of Nations (2002); Weede and Kampf (*Kyklos,* 2002); Volken (2003); Weede (2004), Whetzel and McDaniel (2006), Ram (*Economics Letters,* forthcoming).

- 160 IQ tests, 81 countries over the last 100 years

- ρ(IQ, *level* of Y/L) = 0.73

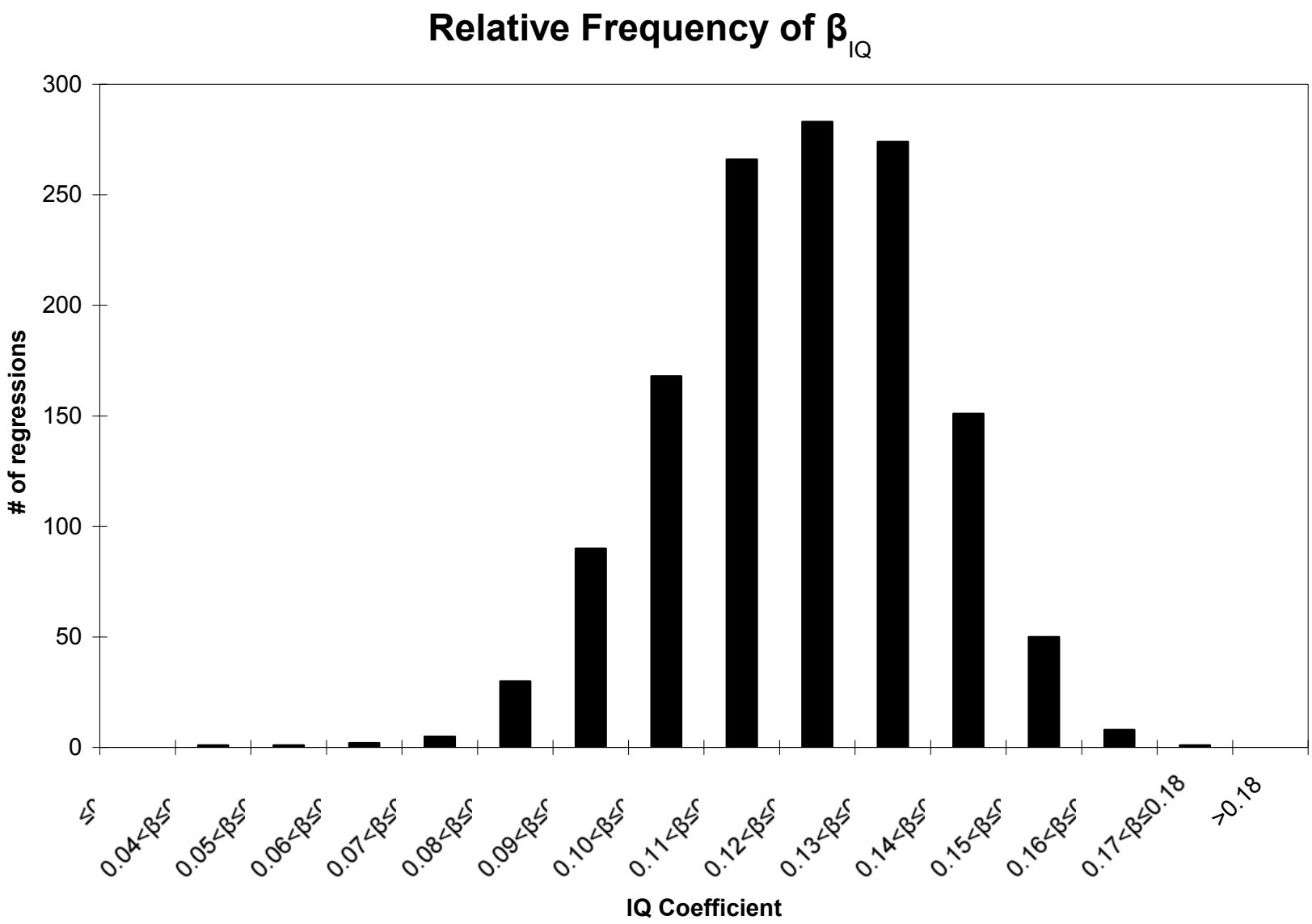
- Global mean IQ=90, Std Dev: 11. (UK Mean≡100, S.D.≡15)

- N.B.: Lynn and Vanhanen have new book (2006): IQ and Global Inequality; 200+ tests, 113 countries, same results.
  (IQ and U.S. States: Kanazawa (2006), McDaniel (2006))

"Intelligence, Human Capital, and Economic Growth"
Jones and Schneider, *J. Econ. Growth*, 2006

Goal: Stack the deck against IQ

- Ran 455 Solow/MRW-style growth regressions: All included IQ.
- Additional Controls: Combinations of 18 growth variables passing Sala-i-Martin et al.'s (AER 2004) Bayesian model averaging test
- IQ significant at 1% level in all 455 regressions
- Mean estimate: 1 IQ point → persistent 0.12% annual rise in Y/L
- In steady state: 1 IQ point → 6% rise in Y/L
- IQ dramatically more robust than education measures
- IQ also easily passed a Bayesian model averaging test: Even if you have a low prior that IQ is robust, the data should change your mind.


Relative Frequency of β IQ
300
250
200
150
100
50
0
# of regressions
≤
0.04<β≤
0.05<β≤
0.06<β≤
0.07<β≤
0.08<β≤
0.09<β≤
0.10<β≤
0.11<β≤
0.12<β≤
0.13<β≤
0.14<β≤
0.15<β≤
0.16<β≤
0.17<β≤0.18
>0.18
IQ Coefficient

Variables passing Sala-i-Martin (AER 1997) robustness test:

1. Equipment Investment +
2. Number of Years Open Economy +
3. Fraction Confucian +
4. Rule of Law +
5. Fraction Muslim +
6. Political Rights +
7. Latin America Dummy –
8. Sub-Saharan Africa Dummy –
9. Civil Liberties +
10. Revolutions and Coups –
11. Fraction of GDP in Mining +
12. Std. Dev. of Black Market Premium –
13. Fraction of GDP in Primary Exports in 1970 –
14. Degree of Capitalism +
15. War Dummy –
16. Non-Equipment Investment +
17. Absolute Latitude +
18. Exchange Rate Distortions –
19. Fraction Protestant –
20. Fraction Buddhist +
21. Fraction Catholic –

Variables Included in all Sala-i-Martin Regressions

Log GDP per capita 1960 – Rate of Primary School Enrollment, 1960+ Life Expectancy, 1960+

Variables passing Sala-i-Martin et. al's (AER 2004) robustness test:

Included in all 455 regressions:

1. log GDP per capita 1960 (log) -
2. Primary schooling 1960 +
3. Investment price −

Included 3 at a time:

4. East Asian Dummy −
5. Fraction of tropical area −
6. Population density coastal 1960's +
7. Malaria prevalence in 1960's −
8. Life expectancy in 1960 +
9. Fraction Confucian +
10. African dummy −
11. Latin American dummy −
12. Fraction GDP in mining +
13. Spanish colony −
14. Years open to trade +
15. Fraction Muslim +
16. Fraction Buddhist +
17. Ethnolinguistic fractionalization −
18. Government consumption share 1960's −

The Next Step: Finding out *why* IQ matters

- First place to look: The human capital literature
- Question:
  Can microeconomic IQ-wage estimates + standard aggregate production function explain the macro-level IQ/productivity relationship?
- Intentionally "naïve"
- Only looks at direct, externality-free effects
- Need γ: Impact of 1 IQ point on micro-level log wages
- We assume γ is the private marginal product of labor:
  Our calibration parameter

U.S. estimates of γ

- Neal-Johnson (JPE, 1996). $\gamma = 1.15\%$
- Bishop (AER, 1989): $\gamma = 1.27\%$
- Zax-Rees* (REStat, 2002): 0.75% (young); 1.4% (middle-aged)
- Heckman et al.* (1997):
  1.3% (black females) to 1% (white males).
- Bowles-Gintis-Osborne (JEL, 2001): avg. 0.5% across studies.
- U.S. estimates typically drop about 1/3 when education is controlled for.

IQ's impact on wages around the world (Behrman et al., 2004)

- 6 developing countries: Mean=0.8%; Median=0.8%

Testing the IQ tests: IQ and immigrant wages

- Hendricks (AER 2002) showed that workers coming to the U.S. from different countries differed widely in their average productivity—country of origin mattered.

- True even after controlling for age and education

- He called this "unmeasured worker skill."

- Can IQ measure this? Does the average IQ of a country predict the average wages of immigrants from that country?

Testing the IQ tests (2)

- A simple test: see if "unmeasured worker skill" for immigrants from a country is strongly associated with the average IQ in that country
- A less simple test: see if the γ matches micro-level studies.
- Robustness tests: endogenous education and outliers.
- N.B. Hendricks shows immigrant self-selection matters little, on average.

Testing the IQ tests (3)

- Standard Mincer-style wage regressions adjust for experience and education only (e.g., Heckman et al. (1997), Zax and Rees (2002)).

- Hendricks has already done this.

Should γ match?

Gould, *Mismeasure of Man* (1981),
Diamond, *Guns, Germs, and Steel* (1999),
Ehrlich, *Human Natures* (2000):

Key message:
Cross-country/Cross Culture IQ tests
are noisy measures of ability, perhaps worthless

<u>If so, my estimate of γ will be biased downward.</u>

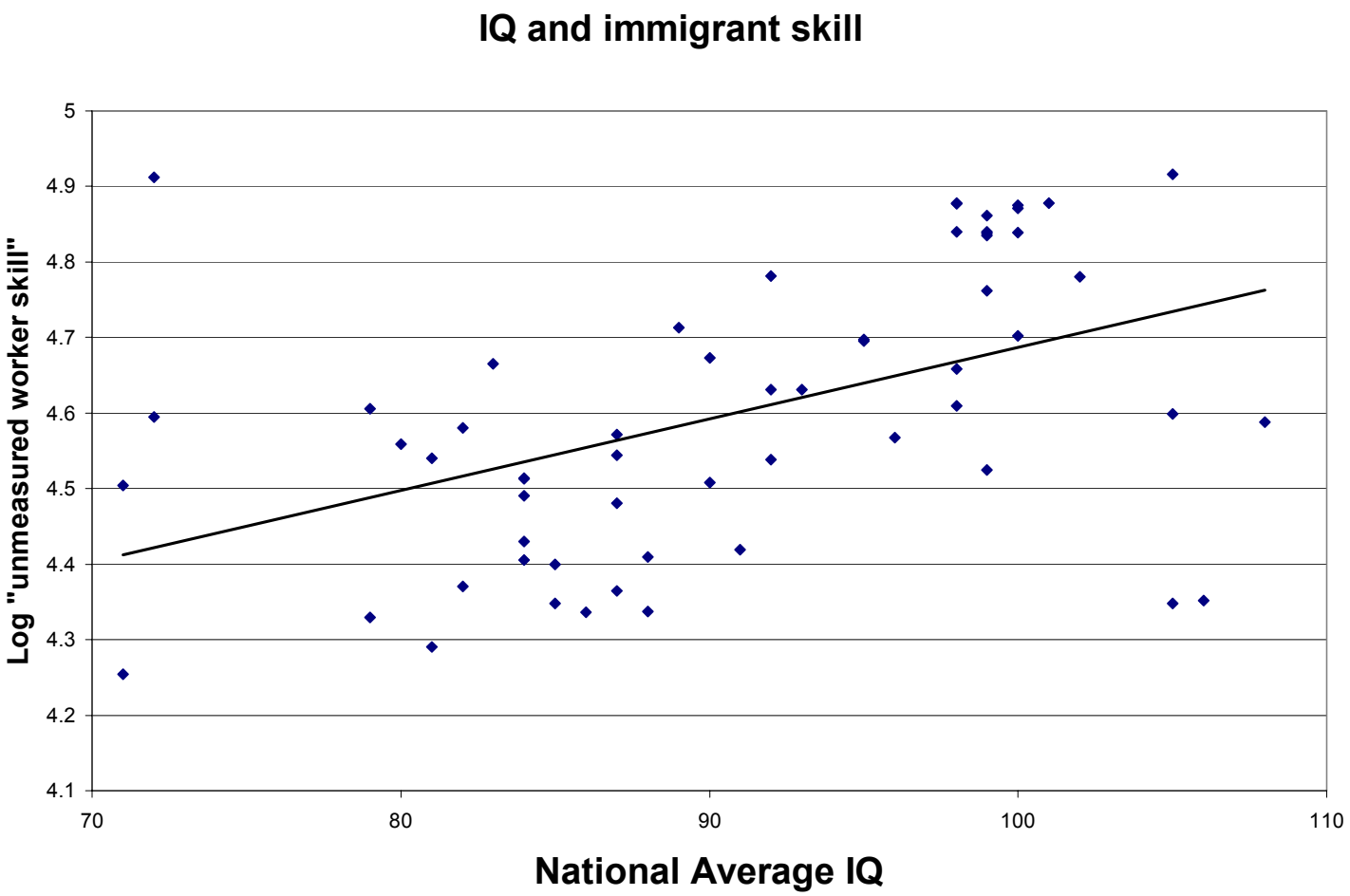
But low IQ in a country may come bundled with other bad, non-IQ traits (e.g., low-productivity culture, poor health).
<u>If so, estimate of γ will be biased upward.</u>

Data from Hendricks (AER 2002)

- 106,263 immigrants from the 1990 Census of Population and Housing.
- Between the ages of 20 and 69 and worked full-time in the U.S.
- Immigrants from 76 countries—data are aggregated to country level.
- Compared the earnings of native-born and immigrant from country *i* with identical ages and identical education levels
- Residual wage difference ≡ "Unmeasured Worker Skill" of workers from country *i*

Summary Statistics from Hendricks (AER 2002)

- Perhaps surprisingly, "unmeasured worker skill" varies widely for immigrants from different countries.
- s.d of log unadjusted wages is 0.29 across 76 countries.
- s.d. of log "unmeasured worker skill" is 0.19 across these same countries.
- Hendricks overlaps with 59 of LV's (2006) national average IQ estimates.
- *Now to the key question*: Does national average IQ measure "unmeasured" worker skill differences?



X-axis: Lynn and Vanhanen (2006).
Y-axis: log of $uws_{i,}$ the unmeasured worker skill estimate for immigrants from country *i,* estimated in Hendricks (2002).
OLS coefficient: 0.95%, R^2 = 22%, t-stat = 4.05

Result: $\gamma \approx 1$

Robustness tests: A quick overview

What about outliers?

- Omitting S. African, Chinese, S. Korean immigrants changes little

What if IQ → Education?

- Using log unadjusted wages changes little

What about geography dummies?

- Including Africa, East Asia, and Latin America dummies makes no difference (robust dummies from S-i-M)

Net result:

IQ predicts similar wage differences within and between countries

> *Immigrants from high-IQ countries behave like representative agents of their home countries.*

IQ in the Production Function

$$Y_i = K_i^{\alpha}(e^{\gamma IQ_i}A_iL_i)^{1-\alpha}$$

IQ_i= national average IQ in country *i*

γ= IQ elasticity of effective labor

$e^{\gamma IQ_i}$ = IQ's impact on effective labor

A_i= All other productivity differences, *including* other channels running from IQ to output.

N.B.: This is the conventional way of modelling human capital's impact on output.

Productivity Accounting with IQ

To isolate the IQ-wage channel, consider case where K/Y is identical across countries: Denote as κ^*

$$\left(\frac{Y}{L}\right)_i = A_i e^{\gamma IQ_i} \left(\kappa^{*\frac{\alpha}{1-\alpha}}\right)$$

N.B. Can think of this as steady-state in Ramsey or Solow model

Accounting for IQ

Taking logs, collecting terms into μ
and solving out log(A) yields:

$$\log\left(\frac{Y}{L}\right)_i = \gamma IQ_i + \mu + \varepsilon_i.$$

- Higher-IQ countries will be more productive in steady-state

Data and Parameter Values

- Consider γ in range from 0.5 to 1.25: 1.0 as preferred estimate
- log Y/L: Log output per worker, PWT, 2000 data, 63 countries.
- Lynn and Vanhanen (2006) IQ estimates from 63 countries.

Using the Model (1): What if IQ were the only difference?

- Gap between 5^{th} and 95^{th} percentiles: 38 IQ points
- Implies a rise in steady-state living standards of:

$$e^{\gamma * \Delta IQ}$$

Impact of 38-point rise in IQ on Living Standards

γ	Rise in (Y/L)
0.5	21%
1.0	**46%**
1.25	61%

- But in the data, countries with 38 more IQ points are 15X richer.
- $e^{7*0.38} \approx 15$, $e^{6*0.38} \approx 10$, $e^{6*0.19} \approx 3$
- Conclusion: 1<6 or 7. Still a lot to explain: IQ externality?

Using the Model (2): Productivity Accounting Results

Variance in year 2000 log Y/L explained by
IQ's impact on marginal product of labor

γ	R^2
0.5	9%
1.0	17%
1.25	20%

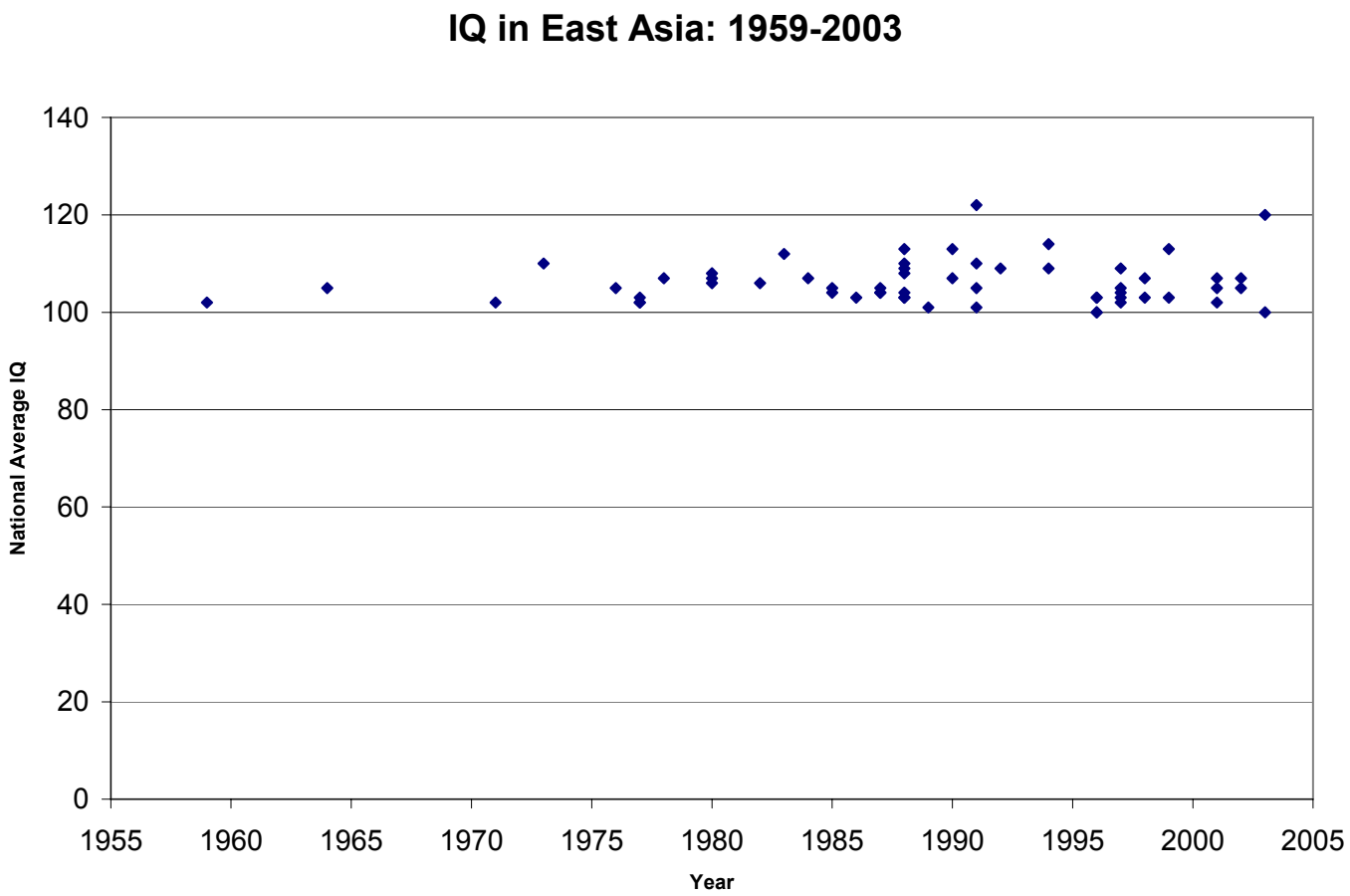
- Conclusion: IQ in the Production Function explains $\approx 1/4^{th}$ of the empirical IQ-productivity relationship

(Recall: OLS R^2=64%: 17/64 ≈ 1/4)

- ***Puzzle: IQ matters more at macro than at micro level***

- Opposite of education literature (cf. Krueger-Lindahl JEL 2001; Sala-i-Martin et al. AER 2004)

Can reverse causality explain IQ's robustness? (1)



Can reverse causality explain IQ's robustness? (2)

Real oil prices quadrupled between 1973 and 1986 before declining: Did Middle East have big IQ gains after mid-70's?

Year	IQ	Country
1957	77	Egypt
1957	82	Lebanon
1959	84	Iran*
1972	81	Egypt
1972	83	Iran*
1972	87	Iraq*
1972	87	Iraq*
1987	80	Iran*
1987	84	Jordan
1987	78	Qatar*
1989	83	Egypt
1992	89	Iran*
1997	85	Yemen
2005	86	Kuwait*

*: OPEC member

Median IQ Pre/Post 1973:
83 and 84

Median IQ in OPEC countries Pre/Post 1973:
85.5 and 83

Difference in differences between OPEC and non-OPEC countries, 1973 break:
-5.5 IQ points: Wrong direction.

The root cause(s) of global IQ inequality:
Culture? Environment? Nutrition? Genetics?

- Survey: Rushton and Jensen (2005), and other authors:
  Journal of Psychology, Law, and Public Policy, online.

- An active area of genetic research:
  - Lahn et al., *Science* (2005a,b); One IQ link refuted in Lahn et al., *Hum. Mol. Gen.* (2007).
  - Wang et al., PNAS (2005), online:

"…..[S]everal predominant biological themes are common in these selected alleles, including….neuronal function….[M]ost of these selective events likely occurred in the last 10,000–40,000 years, a time of major population expansion out of Africa…." (emph. added)

- Wacziarg and Spoloare (2006): Genetic distance between countries may be a barrier to technology diffusion. *Proxy for culture?*

Other IQ→ Y/L channels?

- "Are Smarter Groups More Cooperative? Evidence from Prisoner's Dilemma Experiments, 1959-2003"(Jones, 2006)

- 100 SAT points↔5% rise in cooperation in repeated PD. Why? Patience, Perceptivity, and Altruism (Axelrod, 1984)

- Impatience (Warner and Pleeter, AER '01; Fredrick, JEP '06). Helps explain lower savings rates in poor countries—and higher cooperation in RPD's.

- IQ and intern'l technology diffusion (Jones, in progress). Higher national IQ→Faster TFP convergence, 1960-2000.
  --Beats education in a horse-race.
  --Robust to using pre-1970 IQ scores.

Conclusion

- Average intelligence differs across countries
- Easily verified by brain scans
- Canonical micro result: Higher IQ→ More productivity
- Can explain some of the IQ→Y/L relationship ($1/4^{th}$? $1/7^{th}$?)
- Reverse causation unlikely to be the whole story.
- Needed:
  Quantitative theoretical work exploring new IQ→Y/L channels
- Growth economists who avoid studying global IQ differences may be missing more than half of the story.